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Broadband municipal optical networks in Greece: A suitable business model

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ABSTRACT

This paper proposes a business model for the optimal exploitation of the currently developing broadband metropolitan area networks in Greece. Having recorded and examined relevant international practices, we describe in detail the way that these networks should be managed, operated, maintained and expanded. Taking into consideration that these infrastructures will widely alter the broadband map of Greece, that Greece has currently one of the lowest broadband penetration percentages in Europe and that the proper exploitation strategy of the networks to be deployed could boost the demand for broadband connections and applications, the application of the optimal business model appears to be of vital importance. We describe the proposed business model in detail, including ways for expanding the broadband infrastructures, as well as tackling of viability issues regarding the authority responsible for managing the broadband metropolitan networks.

1. Introduction

On 1st June 2005, the Commission adopted the “i2010: European Information Society 2010” initiative, in order to foster growth and jobs in the information society and media industries (European Union, 2004). i2010 is a comprehensive strategy for modernizing and deploying all EU policy instruments to encourage the development of the digital economy. In Greece, the targets of the aforementioned initiative will be attained through the implementation of the Operational Programme “Information Society”.

This Programme has five (5) Action Lines, including “Education and Culture”, “Citizens and Quality of Life”, “Development & Employment”, “Communications” and “Technical Assistance”. Within Action Line ”Communications”, there have been granted actions for the development of local access network infrastructures and advanced telecommunications services for the citizen. The aim of the specific granted actions is to develop broadband access/metropolitan networks in small towns and non-urban or remote areas, in order to provide a broad range of basic telecommunication services. The development of the broadband infrastructures will be based on a regional strategy level and will take into account the physical particularities, the foreseeable social, economic and population developments, as well as the existing telecommunication infrastructure. However, several questions are arisen, regarding the business model that will be used for the optimal exploitation of these networks (e.g. what will be the role of the municipalities, what will be the degree of government

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interventionism, how is healthy competition going to be promoted, how is the network's viability going to be ensured, etc.).

Taking a look into the globe, broadband metropolitan networks have been developed in various countries around the world, such as Ireland, Sweden, USA, New Zealand, Canada, France, and The Netherlands. Pioneer countries like Canada and Sweden present successful examples on how broadband infrastructure can reinforce the local economy and contribute in further development. Generally, it is difficult to measure the direct impact of broadband infrastructure to local economy and local development but the general feeling is that broadband infrastructures have a strong impact on local economy and development. One of the most remarkable examples on how broadband infrastructure can reinforce the local economy and contribute in further development is the case of Arjeplog in Sweden. Arjeplog is a city in the north Sweden near the arctic cycle with 3.300 inhabitants and has an area similar to Netherland. The broadband fiber optical network which was developed in Arjeplog reinforces the local economy and plays an important role in the economical and social development of the city. Before the implementation of the broadband network the local economy was based mainly in the lead mining and forestry. The development of the broadband network contributed to the creation of new jobs. The faster and better communication infrastructure attracted many car manufactures to create their winter testing facilities in Arjeplog. The above had a significant result in the reduction of the unemployment in Arjeplog.

Lehr et al. (2006) made a first attempt to measure broadband's impact by applying controlled econometric techniques to national-scale data. Their results support the view that broadband access does enhance economic growth and performance, and that the assumed (and oft-touted) economic impacts of broadband are real and measurable. More specifically, Lehr et al. (2006) found that between 1998 and 2002, communities in which mass-market broadband became available by December 1999 experienced more rapid growth in (1) employment, (2) the number of businesses overall, and (3) businesses in IT-intensive sectors.

Moreover, concerning the impact of broadband to local economy, Lehr et al. (2006) said that "once broadband is available to most of the country, differences in economic outcomes are likely to depend more on how broadband is used than on its basic availability. The implication for policy makers is that a portfolio of broadband-related policy interventions that is reasonably balanced (i.e., also pays attention to demand-side issues such as training) is more likely to lead to positive economic outcomes than a single-minded focus on availability."

Concerning the government policies, they would support the competition, and more specifically, the infrastructure competition between DSL and cable TV which according to Höffler (2007) had a significant and positive impact on the broadband penetration. However this is not the case in Greece where DSL is the dominant solution.

According to Picot and Wernick (2007) the role of government in broadband access is important. More specifically they have investigated Europe, Korea and the US which are cases where government involvement differs to some extent. The importance of broadband has become common ground, but the methods of encouraging its development are quite different. They conclude that "successful governmental strategies should consider both, public good and competition-related aspects of broadband. While platform competition seems to have much impact on a high deployment rate, especially in metropolitan areas, LLU can contribute to broadband diffusion in regions and countries lacking of alternative infrastructure."

Very useful empirical research results presented by Cava-Ferreruela and Alabau-Munoz (2006) concerning public policies to promote broadband supply. According to them soft-intervention strategies should be applied, based on the assumption that the most effective policy for accelerating broadband deployment is to promote technological competition (i.e., between DSL and cable networks). However, Cava-Ferreruela and Alabau-Munoz (2006) notice that there are geographic areas that are likely to remain underserved (rural and scarcely populated areas). They propose to follow medium-intervention strategies that consider public funding for infrastructure supply in these areas as more suitable for a balanced broadband coverage in the whole territory.

This is the case for Greece, especially in rural and remote areas of the country, where there is no alternative infrastructure. The broadband metropolitan area networks deployment from the "Information Society" Operational Programme are very important to Greece, since they are expected to boost broadband penetration, which is now at very low levels. Specifically, Greece has shown a significant increase in broadband penetration (77.3%) from January to July 2006, but still possesses the lowest position in Europe (Observatory, 2006), exhibiting 2.66% broadband penetration (July 2006), when, at the same time, the mean value of broadband penetration in the EU (15 members) is 14.46%. In addition, according to OECD (2006), Greece is ranked 30th amongst the 30 most developed countries, while Denmark is ranked 1st with broadband penetration 29.3% (July 2006).

The main objective of this paper is to decide on the most appropriate business model to be used for the optimal exploitation of the Greek metropolitan area networks. More specifically, this paper intends to:

- Present the status of broadband infrastructures in Greece.
- Examine the basic levels of a potential business model to be applied in broadband networks.
- Record international experience with respect to broadband business models for the exploitation of broadband infrastructures.
- Propose specific business models and designate, through comparative analysis, the most appropriate one for exploiting broadband infrastructures in Greece.

2. Status of broadband infrastructures in Greece

The availability of DSL lines in Greece is the lowest among all the OECD countries (less than 10%), when other OECD countries like Korea and Belgium have availability 100% (Fig. 1). This is very important, taking into account that broadband access in Greece is based almost 100% on DSL connections (Fig. 2), as opposed to other countries, such as Denmark and Portugal, where alternative technologies are used. Fig. 3 shows the broadband subscribers per 100 inhabitants in OECD countries from December 2003 to June 2006. It is observed that broadband penetration in Greece has increased significantly during that period; however, Greece has been exhibiting the lowest broadband penetration among the 30 most developed OECD countries every measuring period. Referring to Europe, Greece possesses one of the smallest numbers of broadband fixes access lines, as depicted in Fig. 4.

Regarding the broadband market in Greece, the incumbent operator has decreased its market share from 80% to 60% during the period from July 2004 to July 2006, as shown in Fig. 5. It is worth mentioning that the new (alternative) operators in Greece have made relevant investments mainly in the two biggest cities (Athens and Thessaloniki), while small cities and rural areas are covered only by the incumbent operator.

The above facts make clear that Greece has to severely invest on broadband infrastructures, so as to reduce the gap between the other counties in Europe and OECD. Taking this into consideration, the deployment of the broadband metropolitan

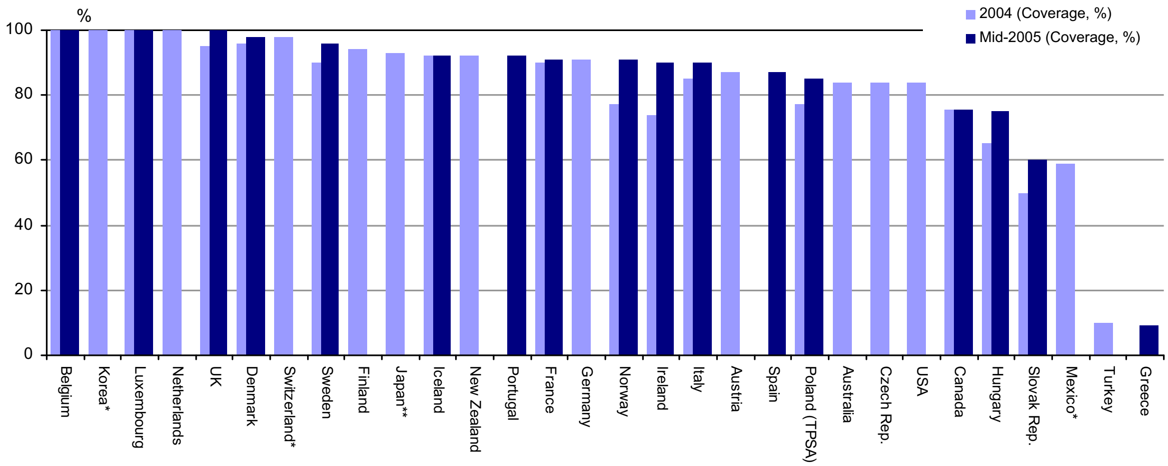

Fig. 1. Availability of digital subscriber lines (DSL) in OECD countries, Mid 2005 (source: OECD).

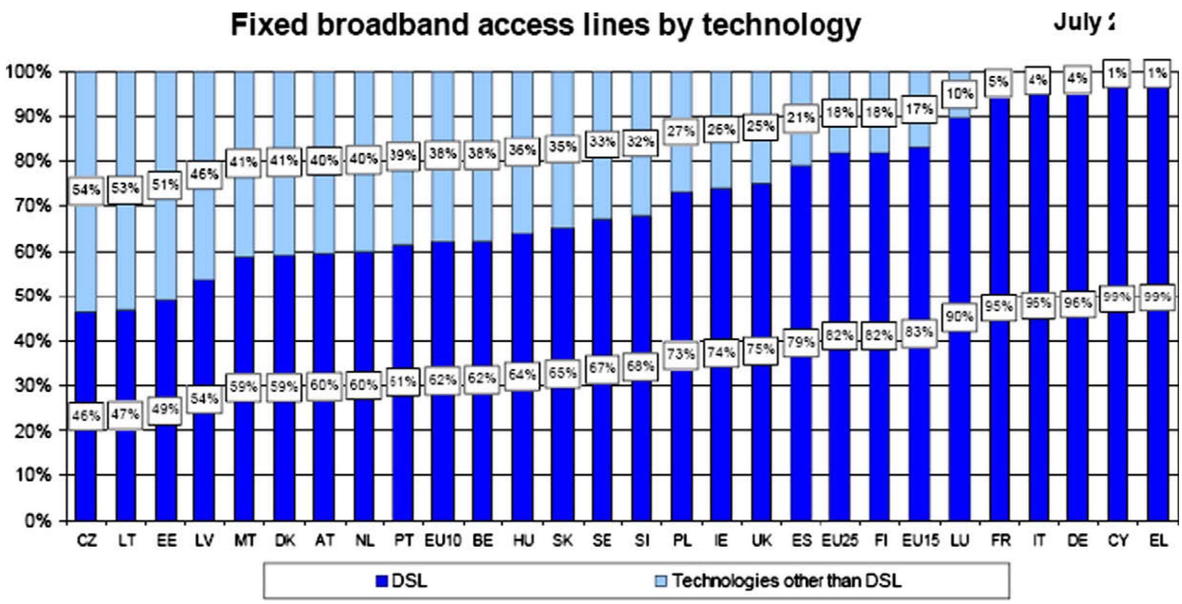

Fig. 2. Fixed broadband access lines by technology (source: European Commission, 2006).

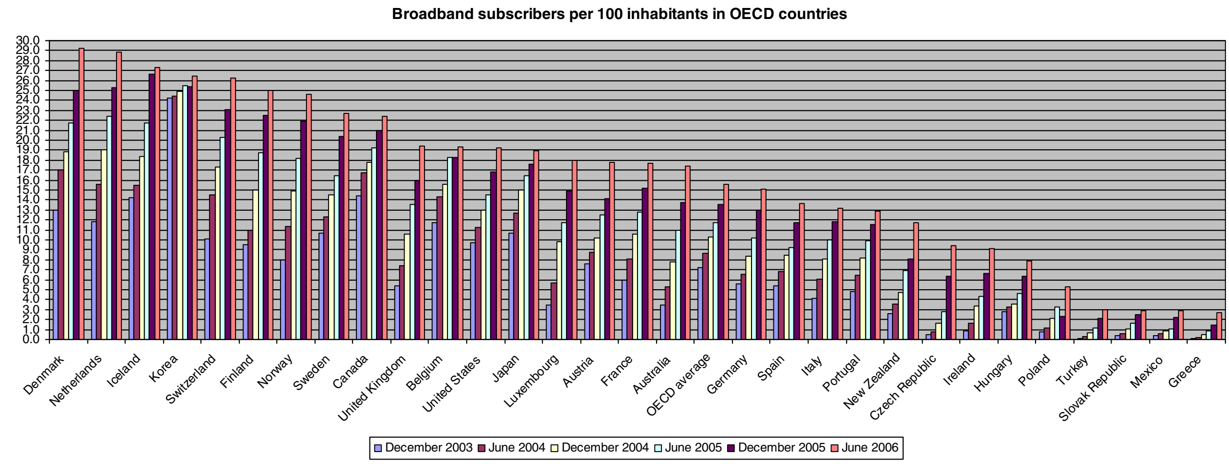

Fig. 3. Broadband subscribers per 100 inhabitants in OECD countries (source: OECD).

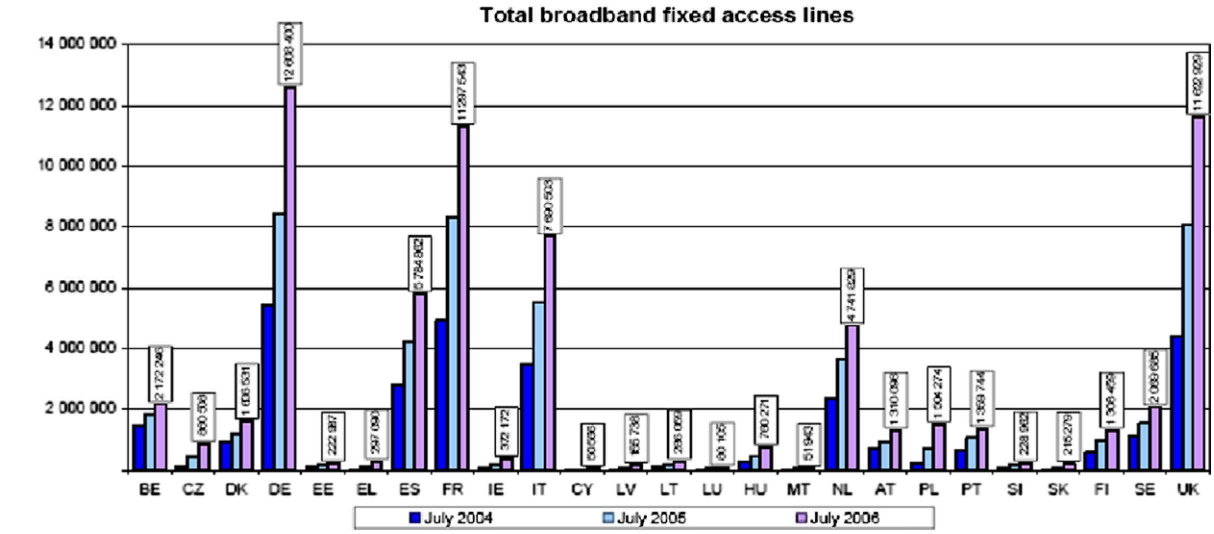

Fig. 4. Total broadband fixed access lines (source: European Commission, 2006).

area networks from the Greek "Information Society" Operational Programme is very important, since it is expected to boost broadband penetration.

The reasons for the limited growth of broadband access networks' development in Greece, as opposed to other countries (Marcus, 2005) are manifold, including some of the ones presented next.

Firstly, the potential market of broadband services in Greece is small. Recent studies (Greek Research and Technology Networks, 2005; Observatory, 2005; Ebusiness Forum, 2005) which concern either small and medium-sized enterprises (SME) in Greece or Greek households, have shown low penetration percentages in personal computers (PC) and Internet possession. The only encouraging outcome of such studies is the increase rates in both PCs and Internet users' penetration; thus, an improvement of the current situation is hopefully going to be anticipated soon.

Secondly, the country's remote areas are the least developed ones and the ones facing the most intense technological exclusion. Long local loops are needed for these areas, due to the country's geographic properties (as compared to much shorter distances required in urban areas). This fact leads to a dramatic increase in the broadband networks development costs and that, in combination with the low anticipated demand in these areas, results in limiting the potential relevant new investments (Bouras et al., 2005a).

The limited terrestrial infrastructure (backbone and access) nowadays in Greece, owned in their vast majority by a single (up to recently, public) vendor (OTE – the Hellenic Organization for Telecommunications), consists an important obstacle in competition development. Unbundling proceeds slowly and the competition in network infrastructures and services provision is, up to now, insufficient (Bouras et al., 2005b). One of the main reasons for this has been the absence of a sufficient regulatory framework, especially regarding the licensing of the telecommunication providers.

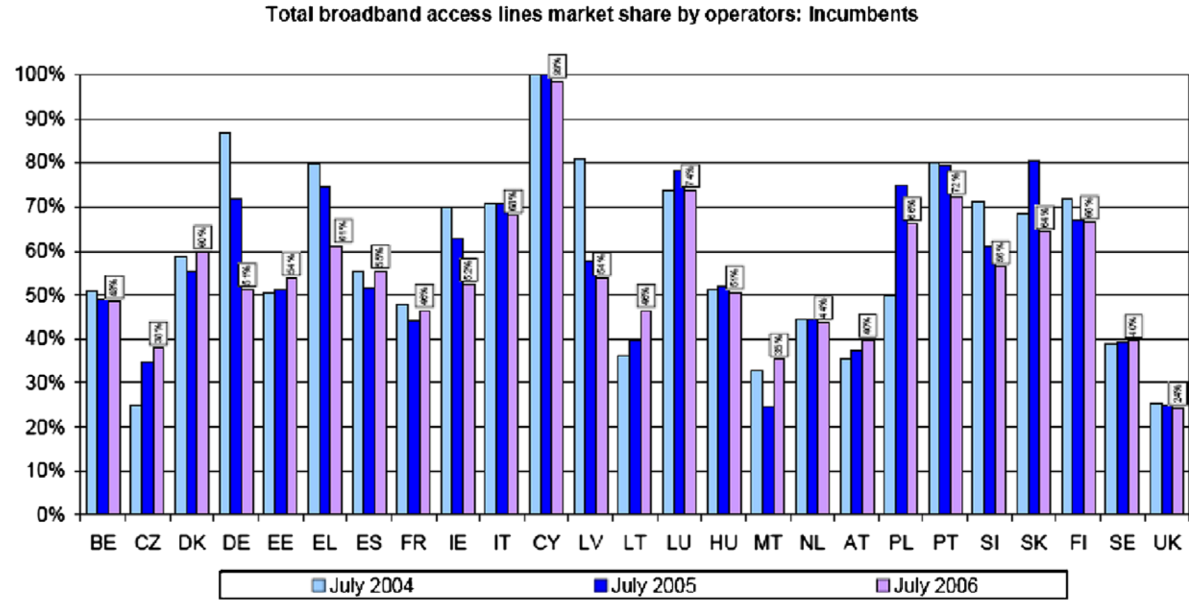

Fig. 5. Total broadband access lines market share by operator (source: European Commission, 2006).

The current broadband infrastructures in Greece are classified in:

- Public broadband networks: These are the Greek Research and Technology Network (GRNET), the Greek Network of National Government ('Syzefxis'), the Greek Universities Network (GUNET) and the Greek School Network (GSN). The aforementioned networks interconnect research and academic organizations, institutes, universities, public utilities and schools.
- Private broadband networks: The low demand for broadband services and the high cost in telecommunications services and Internet access have not permitted any important investments activities in developing alternative broadband infrastructures. Since 2000, alternative providers have developed new broadband infrastructures only within and between the two major cities of Greece, Athens and Thessaloniki.

Towards the direction of implementing new broadband infrastructures, the Operational Programme "Information Society" (Infosoc, 2005) in Greece, funded by the European Community, has planned certain actions, one of which is funding the development of municipal fibre optical networks (dark fibre) in major cities, small towns, as well as in non-urban and remote areas of the country (under a program called "Call 93"). The aim of the proposed infrastructure is to develop metropolitan area networks, in order to provide a broad range of basic telecommunication services. The development of these telecommunications infrastructures will be based on a regional strategy level and take into account the physical particulars, the foreseeable social, economic and population developments, as well as existing telecommunication infrastructure. Prior to the implementation of these networks, a relevant study will take place, recording the current situation in each town and will highlight all the challenging points which require special attention. In addition, for each town, a business model for the efficient operation of the networks will be proposed. The business model will take into account the possibility of providing optical fibre in cost-based prices, in order to cover only the operational and maintenance cost of the infrastructure. The main objective of this paper is to propose such a business model that would be used for the optimal exploitation of the Greek metropolitan area networks. Sixty eight (68) networks will be implemented through "Call 93" throughout Greece, exhibiting total cost of 54 million Euros and total length of 750 Km.

Concerning the implementation technologies, fibre optics and wireless are the two key technologies for such an approach (Burney et al., 2000).

3. International experience in broadband business models

Before proposing a suitable business model for the Greek case, the international experience is presented. In general, broadband metropolitan networks have been developed in municipalities along different parts of the globe. Pioneer countries, such as Canada and Sweden, present examples of how broadband infrastructures can reinforce the local economy and contribute in further development. International experience records various business models (OECD, 2003) on broadband infrastructures exploitation, and a few indicative ones are mentioned in the following paragraphs. These cases are representative for every business model used and will help us to present several different business model scenarios in the next section. It should be noted that the information presented in this section about similar broadband networking projects/actions in various counties has been collected by the web sites of each project.

3.1. Europe

Remarkable efforts in Europe can be recorded in Ireland, Sweden, Austria, The Netherlands and Spain.

3.1.1. The Irish development model

Metropolitan networks are designed as general-purpose networks and not as a technical solution, at least, for a limited number of service suppliers (www.enet.ie). The networks have been selected and designated by the local authorities, in the perspective of social and economic development. The operation of the metropolitan networks is effectuated centrally, through the establishment of a specific service that operates and administrates the networks. The channel network is planned and constructed so that it can support both fibre optic and copper wire infrastructures. In this particular case the open access model has been adopted. The infrastructures constructed belong to the local municipal authorities, while part of the optic fibre network is leased to telecommunication providers at cost-oriented prices. The networks constructed support collocation facilities. The relevant project was implemented during 2000–2006 with a total budget of 200 MEuros.

3.1.2. The Stockholm case (Stokab) in Sweden

Stokab (www.stokab.se) constitutes a business plan, which is being applied in the wider region of Stockholm, Sweden, aiming at the development and operation of fibre optic communication networks, as well as at leasing of fibre optic connections. The Stokab Company was established in 1994 for this purpose and belongs to the Stockholm Stadshus AB group, which, in turn, belongs entirely to the Municipality of Stockholm. The target of Stokab consists in the development of operator-neutral structures with regard to information science infrastructures. The company was supposed to achieve this goal by providing the market with network infrastructures that are going to permit both operators and different service providers to offer their services to the end users. Simultaneously, the same infrastructures will be adequate to cover eventual businesses' and public or private organizations' needs. The total assets incorporated in 2005 was 132 MEuros.

3.1.3. The case of Amsterdam in the Netherlands

In the case of the Netherlands, the implementation of broadband technologies regards also the municipalities of the country. The most indicative example is the case of Amsterdam (www.citynet.nl): The Municipality of Amsterdam opted for fibre optics, considering that copper and coaxial cables are soon going to be obsolete. This action stemmed from the providers' unwillingness to invest in the installation of optic fibres and the implementation of "Fibre to the Home" (FTTH). The model selected is based on the creation of a utility service in which the municipality participates with a 20% percentage, while it owns and exploits the passive network (fibre optic). The other sides participating in the Public–Private Partnership (PPP) are private carriers and companies. The construction (digging) of the network's passive part began as soon as the private partnership regarding the active part of the network was fixed. The network's active part belongs to a private company. The whole budget of Amsterdam's FTTH project (called Citynet) is estimated in 800 MEuros.

3.1.4. The case of Vienna in Austria

The City of Vienna is convinced that ensuring universal access to information –without any digital divide – is a "service of general interest" just as the provision of local traffic networks, water, electricity, gas and other municipal services. It is therefore a task to be performed by the municipality. Rather than establishing an information monopoly, the City of Vienna, starting in 2006, aims to create an open platform – if possible, in cooperation with other interested market participants – that ensures access for all users under equal and fair conditions. This principle applies to hardware and content alike. Over the past years, several thousand kilometres of fibre cables have been laid by various market participants – Telekom Austria, UPC and others, including the city-owned utility companies in charge of energy provision (Wien Energie), the sewer system (WienKanal) and public transport in Vienna (Wiener Linien). They have started talks on the establishment of a joint platform for network construction.

3.1.5. The case of Catalunia

The LocalRet (or Local Network for these Catalonian Municipalities, http://www.localret.net/idiomes/english.htm) was formed in 1998 and its intention is to connect 300 municipalities. The main concept of LocalRet network is that the service providers of the network will be its final operators and among its major stake holders. LocalRet will design a homogeneous network for all Catalonia, at least at the passive infrastructure level. This will be open and parallel to Telefonica's network. LocalRet will start integrating the small parts of the networks that the municipalities and the Generalitat (government) control, as part of their ownership of railways, highways, streets etc. LocalRet will design Metropolitan Area Networks (MANs) in every city with more than 10.000 inhabitants. The MANs are constructed with fiber optic cables, and is expected to enable service in the areas close where the cable passes. The MANs are also providing what we call street services: TV cameras for security and traffic management, light control, traffic light control, etc. We think of it as something the Mayors can see and touch and very important show as an immediate result for all citizens.

3.2. United States (US)

In the US, the cases of the State of Utah (UTOPIA network, www.utopianet.org) and the city of Philadelphia are of great interest, concerning the successful application of business models for exploiting broadband metropolitan area networks.

In the State of Utah, eighteen (18) cities have committed to ensure that citizens and enterprises will keep on being successful and competitive in the 21st century, by securing access to advanced telecommunication services. For this reason, they established the Utah Telecommunication Open Infrastructure Agency (UTOPIA) on April 2002. UTOPIA (UTOPIA, 2003) will develop the infrastructure and will install fibre optic connections to every house and enterprise, while it has the status of an independent governmental agency, being able to issue bonds to develop the network, at an estimated cost of $400 million. Private contractors will undertake the construction of the network and will participate in its operation. All important parts of the network have been funded by the government. The UTOPIA business model is classified as an open access/wholesale provider model, which becomes feasible through the interlocal agreement among the participating communities.

Apart from the UTOPIA project, in the USA, municipal fibre optic networks are being developed in fifteen (15) states, while wireless networks have been realized in 30 states.

The attempt of creating a huge wireless network in the city of Philadelphia presents special interest. The Wireless Philadelphia Project (Wireless Philadelphia, 2005), started in July 2004, received both public and private funding and its target was the provision of wireless access in the whole city, so as to surpass the digital gap and improve the quality of life of all residents. Steps have been taken towards the direction of establishing an organization that assigns the network's planning, development and administration to private companies. The same organization will provide network access to service suppliers, who will, in turn, offer services to subscribers.

3.3. Other countries

Except from Europe and the US, remarkable efforts are tracked in other countries as well, such as Canada and New Zealand.

3.3.1. The case of Canada (CANARIE, www.canarie.ca)

The great majority of the current and proposed initiatives for the encouragement of broadband infrastructure development in Canada may be classified into two different broad strategies: the demand aggregation model and the public infrastructure support model. The former promotes collective regulations that aggregate the demand for broadband services, on a community or even larger scale, so that the scale economies required for the development and support of a broadband network are achieved. The latter is based on direct public funding for the construction of broadband infrastructures. Although these two models can be applied independently, they are combined in many cases. Since 1993, the Canadian advanced network CANARIE has contributed in the upgrading of the existing network-backbone with regard to research, development and education. The CANARIE partnership was set up with equal participation of the public and private sector. Both private and government funds supported remarkable projects in the sectors of e-commerce, e-business, e-learning, e-science and e-health.

3.3.2. New Zealand: The case of Wellington

The CityLink Company (www.citylink.co.nz/) was established by the Municipality of Wellington in 1995, New Zealand, aiming at the development of a low-cost telecommunication network, intending to offer a comparative advantage to the local enterprises and governmental organizations. This network provides the citizens of Wellington with a variety of services, but it also gives massive company users and Internet Service Providers (ISPs) the possibility to lease part of the network (dark fibre) at cost-oriented prices. One of the innovative and most interesting network features, which contributes enormously in its viability, is that it uses low-cost passive and active equipment (i.e. Zebra on Linux), and not expensive commercial network devices.

Table 1 summarizes the features of the aforementioned business models.

4. Broadband business model scenarios

In this paper, a business model determines the way in which the exploitation of a metropolitan, community-owned, optical network will be effectuated. The objective of the selected business model is similar to the one expressed by Henderson and Ball (2005) and includes the following:

- Determination of the role of the municipality and the region.
- Ensure healthy competition.
- Define the degree of involvement of the private sector.
- Ensure the viability of the metropolitan community-owned optical network.
- Secure the resources for its operation, maintenance and expansion.
- Promote competition for offering better and cost effective services to the citizen.

Table 1
Representative business models and their basic features.

Business models	Features							
	Irish model	Stokab	Amsterdam	UTOPIA	CANARIE (Canada)	Vienna	LocalRet	Wellington
Public carrier					x			
Local carrier (municipality, community, etc.)	x	x	x		x	x	x	x
Private carrier			x		x			x
Consortium			x	x			x	x
Dark fibre network	x	x	x	x		x	x	x
Last mile connections			x	x		x		
Government funding	x		x	x	x	x	x	
Private support			x		x			
Collocation facilities	x	x					x	
Leasing to telecommunication providers	x	x		x		x	x	x
Supply of services		x			x	x		x

Municipalities may play a critical role in enabling the deployment of broadband infrastructures by the private sector, by Government of Sweden (2006):

- Placing open conduit under all freeways, overpasses, railway crossings, canals and bridges.
- Allow over lashing of fibre on existing aerial fibre structures.
- Forcing existing owners of conduit such as electrical companies, telephone companies, etc to make 100% of their conduit accessible to third parties.
- Coordinate construction of all new conduit, especially building entrances to minimize the "serial rippers" and make all such conduit open to third parties.

Fig. 6 presents the three basic levels of a relevant business model:

- The first level determines who (a private or public enterprise, etc.) exploits the network's passive equipment (channels, optical fibres etc.).
- The second level determines who provides and exploits the active equipment of the network (switches, routers etc.).
- The third level determines who offers access to the network, the services and the content.

According to Hughes (2003), the following main Local and Regional Models for Broadband Deployment have the characteristics, advantages and disadvantages presented in Table 2 (with reference to Fig. 6).

In order to conclude to the optimum business model type to be applied in the case of the Greek metropolitan area networks, one should consider that:

- The competition among service providers is beneficial for the consumers not only for financial reasons but also due to the ability to provide a wide variety of services.
- In Greece, the majority of the service providers do not afford to own their private telecommunication infrastructures.
- If a single incumbent holds and manages one level of the network in Greece (either the passive equipment, or the active equipment, or the services), it is difficult to ensure (through a strict regulatory frame) the equal treatment of the competitive alternative providers in the other levels.

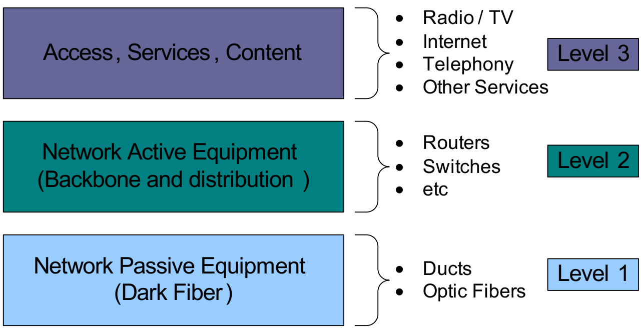

Fig. 6. The basic levels of a business model.

Table 2
Comparison of local and regional models for broadband deployment.

Model	Description	Advantages	Disadvantages
Community operated network and services	All three levels are created and managed by the public sector	Complete solution	– Negative impact on competition in services and networks – Financial risk for the public sector – Public sector needs great technical and commercial expertise
Carrier's carrier model	The public sector develops and manages both Level 1 and Level 2. Level 3 is subject to competition	Lower market entry for service providers	– Possible negative impact on technologies competition – Financial risk for the public sector – Public sector needs to find technical expertise and support
Passive infrastructure model	The public sector develops and manages Level 1. Both Level 2 and Level 3 are subject to competition	Public intervention at the lowest level of the value chain (which, however, represents 70% of the cost of a new fixed network)	– Entry barriers for network operators remain sizeable – Financial risk for the public sector
Aggregation of public demand	Coordinate efforts, exerted by regional carriers and aiming at aggregating broadband services' demand. The regional carrier presents the aggregated demand as an attractive clientele basis to the service suppliers, with whom it negotiates the overall purchase of broadband services and the percentage ownership upon the infrastructure	– No financial risk for the public sector – Limited need for technical expertise within public sector	– Possible negative impact on competition – Exclusive supply agreement for more than 30% of market likely to be anti-competitive – It improves the business case for one operator but destroys the business case for everybody else in that area

- The limited terrestrial infrastructure (backbone and access) nowadays in Greece, owned in their vast majority by a single (up to recently, public) vendor (OTE – the Hellenic Organization for Telecommunications), comprises an important obstacle in competition development. Unbundling proceeds slowly and the competition in network infrastructures and services provision is, up to now, insufficient (Bouras et al., 2005b). One of the main reasons for this has been the absence of an effective and strict regulatory framework.
- Furthermore, the activity of the alternative providers in rural and not large urban areas in Greece is very limited either non-existent. The main reason for that is the fact that the investment in telecommunications infrastructures in these areas is not envisaged being profitable.

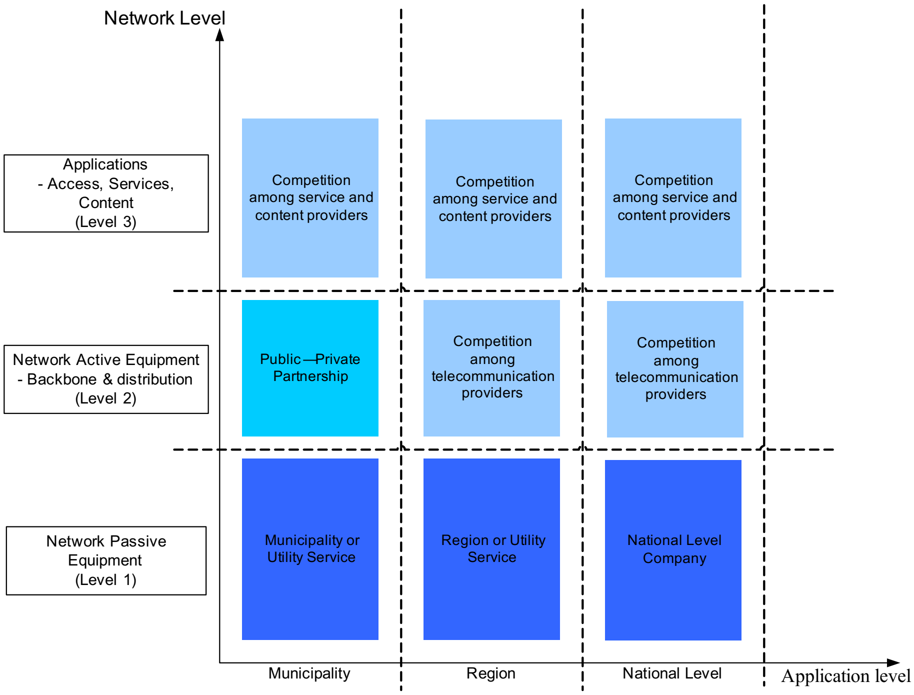

Fig. 7. Business model scenarios for Greece.

- Full governmental control (from the infrastructures to the services level) is regarded as a temporary solution, which would lead to the provision of very limited services to the consumers and would not, in any case, promote the competition.
- Each telecommunication provider has its own active equipment, that is possibly advantageous in relation to its competitors.
- The metropolitan networks that are developed within the frames of "Call 93" in Greece belong to the Municipalities where they are deployed. Thus, it makes sense to propose that the network passive equipment (first level) will be managed by a governmental (municipal, regional or national) enterprise. The provision of this passive equipment in a cost effective way to the telecommunication providers, may probably attract the latter ones to be active in these areas, due to the fact of the limited required investments (that will only concern active equipment).

Taking the above into consideration, the "passive infrastructure model" is highly recommended for the Greek case. In that case, the network's passive equipment (Level 1 – Fig. 6) is proposed to be public, while it is optimal to let the competition act in the two upper levels of Fig. 6 (active equipment and services), setting up the requirements for the provision of many, different and cost effective broadband services to the end users.

There are three alternatives concerning who will take action in Level 1, i.e. manage, maintain, exploit and expand the passive infrastructures:

- Municipal enterprises (where the business model will be applied in municipality/community level).
- Enterprises per region (where the business model will be applied in region level).
- Nationwide enterprise (where the business model will be applied in the whole country overall).

Concerning Level 2 (Fig. 6), anyone will be able to install its active equipment and sell bandwidth (after leasing part of the network's passive part – Level 1). Finally, on Level 3, action will be taken by multiple service suppliers, competing to offer broadband services to the users.

The three alternatives are depicted schematically in Fig. 7.

4.1. The proposed broadband business model applied in municipality level

According to this particular solution, every town (i.e., municipality) will have to proceed to the establishment of a municipal enterprise, which will be responsible for elaborating the business model for exploiting the broadband infrastructures deployed in its area.

In accordance with the preceding analysis, a viable business model for the creation and exploitation of broadband infrastructures and services, applicable in municipality level, should bear the following characteristics (Fig. 6):

- On the first level, action will be taken by the municipal enterprise, implementing and supplying the network's passive equipment.
- On the second level, action will be taken by a single supplier, namely a consortium of private enterprises and telecommunication providers, in which the municipal enterprise will also participate, though with low percentage. This particular Public–Private Partnership will implement and supply the network's active equipment.
- On the third level, action will be taken by multiple service suppliers, competing to offer broadband services to the users.

An obvious disadvantage of this alternative is the foreseen difficulty in interconnecting the optical MANs to each other. Each Municipality will be responsible for its own passive network, so (a) different policies will be adopted for each MAN, (b) there will be no planning for interconnecting these MANs to each other, (c) there will be no provisioning for connecting the MANs to other broadband networks, currently being developed throughout Greece, and (d) municipalities that possess limited number of potential customers will be under-developed.

These four points will make these networks less attractive to the telecommunication providers, since they will offer the capability of exploiting them only in municipality level.

Additionally, it should be stressed that the creation of municipal networks may lead to financial failure, as it is not always possible to ensure direct profits from their usage in the municipality level.

4.2. The proposed broadband business model applied in regional level

According to this solution, every Region will have to proceed to the establishment of a "regional" enterprise, which will be responsible for elaborating the business model for exploiting the broadband infrastructures deployed in its area. The regional enterprise will bear the same responsibilities mentioned in Section 4.1 regarding the municipality level, but in this case covering the whole area of the region (all the municipalities included within its borders).

According to this model proposed, all citizens will be treated on a parity base. Telecommunication providers will pay cost-based fees to the regional enterprise for using part of the network and supplying end users, carriers and enterprises with their services. These services will be of a lower cost, compared to the existing ones, since competition will prove beneficial for the consumers. If this is not the case, the regional enterprise should have the authority to define an upper price limit in order to protect the consumers.

In accordance to the preceding analysis, a viable business model for the creation and exploitation of broadband infrastructures and services, applicable to regional level, should bear the following characteristics (Fig. 6):

- On the first level, action will be taken by the regional enterprise, implementing and supplying the network's passive equipment.
- On the second level, action will be taken by multiple suppliers, leasing the network's passive part and providing the network's active equipment.
- On the third level, action will be taken by multiple service suppliers, competing to offer broadband services to the users.
- This alternative presents similar interconnection/connection problems, as in the Municipality case, but in the regional level instead.

It is however more advantageous than the previous one, since a number of networks will be managed by a single authority (technological and strategic uniformity), there will be municipal networks interconnection within a Region, while the networks in less competitive areas will be supported by the operation of the most competitive ones (in the same region). Economies of scale will also reduce the operational costs, due to uniformity in several sectors.

4.3. The proposed broadband business model applied in nationwide level

According to this particular solution, the Greek State will have to proceed to the establishment of a national company (e.g. National Broadband Enterprise SA – NBE SA), which will be responsible for elaborating the business model for exploiting the broadband infrastructures deployed in the whole of Greece. NBE will bear the same responsibilities as the municipal or the regional enterprise (Sections 4.1 and 4.2, respectively), but in this case covering the whole country.

The role of the NBE SA will be focused on the operation, maintenance, extension and interconnection of the developing broadband infrastructures. The revenues required for the continuous expansion of the networks will derive from the fees paid by the operators in order to lease network resources.

This specific scenario (Fig. 6) aims at the exploitation of the passive part of the network by a public utility service. In particular:

- On the first level, action will be taken by the National Broadband Enterprise SA – NBE SA, implementing and supplying the network's passive equipment in a cost-basis.
- On the second level, action will be taken by multiple suppliers, leasing the network's passive part and providing the network's active equipment.
- On the third level, action will be taken by multiple service suppliers, competing to offer broadband services to the users.

Compared to the two previous business models (municipality and regional level), this one presents obvious advantages:

- NBE SA will be able to design (a) networks' expansion within the Municipalities, (b) connection of MANs to each other, and (c) connection of MANs to other broadband networks.
- Less competitive Municipalities will be able to expand their networks as well, since management will be central and part of the resources from other, competitive Municipalities may be used.
- The telecommunication providers (Fig. 6 – Level 2) will lease the passive infrastructures from NBE SA, offered a common pricing policy (on a cost-basis) for every part of the network. In this way, pricing, as well as all relevant procedures will be simpler for all parts.
- The service providers (Fig. 6 – Level 3) may offer their services, potentially, in national level, having the ability to reduce their prices.
- Management will be easier, since the passive network infrastructure and the expanding strategy will be uniform across Greece. Economies of scale act in a beneficiary way.
- Everybody will benefit form other participants' success; therefore everybody will turn the wheel towards the same direction.

5. Proposed business model

As a result of the above comparison, the most appealing business model for Greece seems to be the one applied at national level. The financial and operational aspects of this business model are analyzed in more detail in the following paragraphs.

As depicted in Fig. 8, competition exists among private companies in the two upper levels (services and active equipment), while the NBE is responsible only for the first level (passive equipment).

Table 3 presents briefly the proposed business model, showing the relevant stakeholders, roles, costs (Capital Expense – CAPEX and Operation Expense – OPEX) and the revenues in each layer (services, active network equipment and passive network equipment).

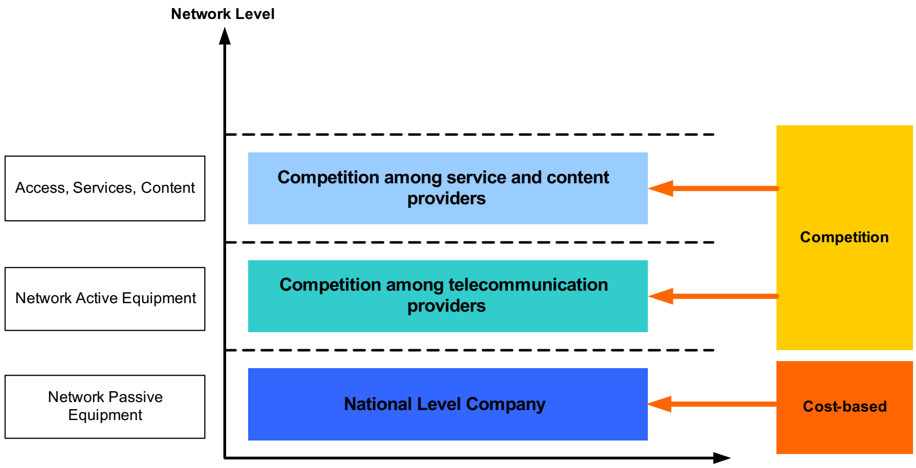

Fig. 8. The proposed business model.

NBE SA will have two roles: (1) monitoring the broadband networks operation and maintenance and (2) monitoring and design the networks expansions.

5.1. Network management

Regarding the network management sector, NBE will be responsible for the infrastructure management and policy-making activities.

NBE infrastructure management activities include:

- Adding new users (telecom providers) to the NBE broadband network infrastructure.
- Operating the network's passive and elementary active equipment (e.g. switches).
- Resolving collocation issues of the customers (i.e., telecom providers).
- Offering and managing information systems (e.g. for recording the deployed network through GIS, for remote management of the collocation points and the network nodes etc.)

Table 3
Stakeholders, roles and costs in the proposed business model.

Characteristics/ layers	Level 1 (passive network equipment)	Level 2 (active network equipment)	Level 3 (services)
Player Roles	NBE SA Core network operator/provider (only for passive network equipment)	Private companies – Access network provider/operator – Core network operator/provider (only for active network equipment)	Private companies – Service provider – Service Integrator – Value-added service provider – Content aggregator – Content provider – Content producer/owner
CAPEX	Passive network equipment Excavation costs	Active network equipment	(n/a)
OPEX	– Maintenance of equipment and components – Network management – Charging and billing – Customer provisioning and care – Regulation	– Maintenance of equipment and components – Regulation – Customer provisioning and care – Network management – Marketing, charging and billing – Equipment and software licenses, maintenance outsourcing	– Sales and marketing, charging and billing – Customer provisioning and care – Services management – Product/platform development – Content – Rental of physical network resources – Regulation
Revenue	Revenues from leasing the physical network resources	Revenues from the rental of telecommunication services subscribers	– Content usage revenue – Services usages revenue – Internet access revenue

NBE policy-making activities include pricing of NBE services, marketing and customer support. It is important to mention that the pricing policy of NBE must be cost-based, in order to provide its services to the telecom providers in attractive prices. Following this approach, the NBE will also ensure that the end user will be offered broadband services at low prices.

5.2. Network maintenance

Concerning network maintenance, NBE will be responsible for the passive network equipment (fibre optics, micro-tubes, patch panels etc.) and the supportive active equipment at the nodes (UPS, security systems, remote control units). Additionally, NBE will be responsible for the elementary active equipment that will have been initially be installed for the public building connection (Ethernet switches, CPE and wireless connection equipment).

5.3. Network expansion

Long term target of NBE is the expansion of broadband networks in several (parallel or not) phases, in order to finally offer Fibre to the Home (FTTH) to each household. The network expansion includes the following phases:

- First phase: initial implementation of the broadband municipal networks in Greece (public funding under the Operational Programme "Information Society", "Call 93").
- Second phase: expansion of the broadband municipal networks, so as to cover more points within the municipalities they are implemented in.
- Third phase: interconnection of the broadband municipal networks, implemented in the two previous phases.
- Fourth phase: FTTH for each household.

5.4. Viability of NBE

This paragraph discusses the viability issues of NBE concerning mainly the cost estimations and financial planning, as well as the risk analysis.

5.4.1. Cost Estimations and financial planning

The financial cost of a broadband network is divided in two parts; the network implementation cost (known as CAPEX – Capital Expense) and the operation and maintenance cost (known as OPEX – Operation Expense).

Initial CAPEX will be covered by public funding. An open issue is how the CAPEX for future network extensions will be funded, since NBE will operate in a cost-basis fashion. Having in mind that broadband access is a public commodity and should be treated like that, we propose the specific CAPEX to be covered by public funding and by the network users. Additionally, it is proposed that the network users should pay an one-time-fee for the connection to the network. One part of this fee will cover the required operations for the connection of the user to the network, while the other part will be used for future extensions of the network. It should be pointed out that this connection fee must be set so as to be low enough, in order not to hold back broadband penetration to the end users.

In order to keep the CAPEX low the following guidelines must be followed:

- Detailed planning of the network.
- Detailed planning of required equipment (logistics).
- Usage of flexible techniques (e.g. usage of micro-ducts, etc) in order to ensure easy and cost effective upgrade of the network.
- High penetration to the end users (resulting in low CAPEX/user).

The CAPEX for the construction of the broadband Metropolitan Area Networks in Greece consists of the following sub-costs:

- The sub-cost for network construction which includes the excavation works, the manhole construction, the supply and installation of ducts and micro-ducts and the supply and installation of optical fibre cables.
- The sub-cost for network nodes construction which includes the supply and installation of nodes housings, the supply and installation of passive equipment staging, the supply and installation of active equipment staging, the supply and installation of needed active equipment, the supply and installation of UPS devices, the supply and installation of air conditioning systems and supply and installation of access control systems for nodes housings.
- The sub-cost for passive equipment installation to users premises which includes the supply and installation optical fibre termination boxes.
- The sub-cost for wireless equipment which may be needed (for connecting distant users to the network) and includes the supply and installation of antennas, and active equipment.

The total cost for the construction of broadband Metropolitan Area Networks in Greece is the summary of the above sub-costs. The calculation of each sub-cost can be found with the use of the Tables 4–7 presented in the appendix after someone complete the running cost of each equipment during the construction period (in this paper, we have complete the following tables with August 2006 prices).

One other approach to estimate the CAPEX per network kilometre for the case of NBE is to divide the total founding of the "Call 93" program by the total kilometres of the broadband networks deployed under that call (the prices stand on 2004):

$$\text{CAPEX/km} = \text{total founding/total kilometres} = 58.217.805,78\text{Euro}/740,63\text{Km} = 78.605,79\text{Euro/Km}$$

The aforementioned approach has the advantage of providing a weighted average on the broadband networks deployment. On the other hand, it exhibits two major disadvantages:

(a) It includes (i) the costs for the deployment of a large number of fibres per cable, possibly larger than the number that will be used in a limited network expansion and (ii) the costs for building access and distribution nodes, which will also be limited for a small network extension.

(b) The municipal networks built within "Call 93" in Greece have spare infrastructures (empty micro-tubes for future use) that are included in the aforementioned cost. This means that the real cost for a limited network expansion will be lower.

Concluding, the network extension cost, under normal circumstances, will be lower than the calculated cost with the previous methodology. Someone may claim that this cost is the upper limit for the network expansion.

Additionally, the above cost it is expected to be reduced due to the following facts: (a) the cost of the passive and active equipment was significantly reduced during the last year and (b) the co-installation with other public infrastructures (e.g. water supply or sewerage) will further reduce the installation cost. Our estimation is that during 2007 the above cost will be varying from 45.000 to 50.000 Euro/Km.

The network expansion cost can be divided in two general categories; (a) cost for network expansion in areas with no broadband access (e.g. adding new areas to city plan) at all, and (b) cost for network expansion in areas where initial network infrastructure exists (e.g. expansion of access network).

Concerning (a), network expansion cost estimation can be based on the aforementioned cost analysis for the initial network deployment.

Concerning (b), the network's expansion cost varies, depending on the penetration of the existing network to the area where the network expansion is being planned. E.g. expansion of the distribution and access networks have higher cost than connecting new users to an existing access network. We have the following expansion scenarios:

- Case 1: expansion from and existing users' concentration manhole.
- Case 2: expansion from and existing distribution manhole.
- Case 3: expansion from a new access or distribution manhole.

In Case 1, the cost for network expansion from an existing users' manhole can be done with the use of the Table 8 in the appendix. The following table contains all the necessary activities for adding a new user to the network from an existing users' manhole. As result someone can use the running cost of each activity during the expansion period in order to calculate the expansion cost with the following equation:

$$K1 = 1 * A1 + X * A2 + X * A3 + Z * A4 + 1 * A5 + Y * A6 + 1,05 * (X + D) * A7 + 1,05 * Y * A8 + 1,05 * (X + Y + D) * A9 + 1 * A10 + 4 * A11 + 1 * A12$$

where:

$K1$ is the cost for adding a new user to the network
X the length of the needed trench
Y the length of the needed infrastructure in user premises
Z the number of the needed manholes
D the distance of the closest optical connection (in the case where an optical connection already exists in the concentration manhole $D = 0$).

In Case 2, the cost estimation for expansion from and existing distribution manhole can be done with the use of the Table 9 in the appendix. The following table contains all the necessary activities for adding a new user to the network from an existing distribution manhole. As result someone can use the running cost of each activity during the expansion period in order to calculate the expansion cost with the following equation:

$$K2 = 1 * B1 + B * B2 + C * B3 + X * B4 + 2 * (B + C) * B5 + 3 * (B + C) * B6 + (B + C + X) * B7 + E * B8 + F * B9 + Z * B10 + 1 * B11 + Y * B12 + 1,05 * (X + B + C + D + Y) * B13 + 1,05 * (X + B + C + D) * B14 + 1,05 * Y * B15 + 1 * B16 + 4 * B17 + 1 * B18$$

where:

$K2$ is the cost for adding a new user to the network
B the length of the needed trench type X1
C the length of the needed trench type X2
X the length of the needed trench type X3
E the number of the needed manhole type F1
F the number of the needed manhole type F2
Z the number of the needed manholes in user premises
Y the length of the needed infrastructure in user premises
D the distance of the closest optical connection (in the case where an optical connection already exists in the concentration manhole $D = 0$).

In Case 3, the expansion from a new access or distribution manhole is the same with Case 2 with an extra cost the cost of the construction of the new access or distribution manhole.

OPEX includes network maintenance, billing and pricing and customer support. OPEX can be estimated as a percentage of the CAPEX and a general assumption for NBE is that the OPEX is estimated to be the 2% of the CAPEX. The OPEX funding must be covered by the passive infrastructure users (telecommunication providers) in a cost-based approach.

5.4.2. Risk analysis

According to the proposed business model, the network providers (operating in Level 2) shall make significant investments in active equipment, even though the passive equipment will be leased to them in a cost-basis fashion. Having in mind that investing in broadband network active equipment is costly and highly risky, several telecommunication providers may not decide to invest on municipal broadband networks that might not show the anticipated demand. This will have as a result that some municipal broadband networks (especially in small cities or remote areas) will attract either very few network and service providers or, in the worst case, no providers at all. In order to overcome this risk, promotion campaigns will be organized in order to inform the citizens about the benefits of the broadband networks, contributing thus to the efforts of the Greek state to persuade the public that broadband penetration will improve their lives. Additionally, the cost-based pricing of NBE will contribute to ensuring small fees for the end users.

6. Conclusions

This paper proposes an optimal business model for the effective exploitation of the currently developing broadband metropolitan area networks in Greece. The main objectives of the proposed business model are the following:

- The passive network infrastructure may be used by a large number of service providers.
- The users have the choice of selecting one of the multiple service providers, according to their needs.
- Management of the infrastructure is performed by a neutral operator.
- Low operational expenditure (OPEX) and capital expenditure (CAPEX) are ensured.
- Financial viability of all parts of the infrastructure is secured.

The neutral operator is of critical importance for the business plan, since:

- It secures financial viability of the owners of the infrastructure.
- It reduces the needs for high initial investments from the service providers and, at the same time, it increases considerably the availability of economically accessible services for the citizens.
- It is responsible for fair revenue sharing to all participants in the enterprising scheme.
- It plans and implements networks expansion.

In the proposed business plan, the services providers should focus on providing economical and competitive services without caring for the development of the broadband infrastructure. The ISPs will be able to invest on broadband services and provide them at reasonable prices, as the pricing of the infrastructure they lease will be cost effective. This also concerns the pricing of "dark fibre", as well as any other "lit fibre" service (Peitz, 2003). Finally, as far as the subscribers concern, the presented business plan ensures that:

- There is no relationship between the owners of the infrastructure and the services provided to the subscribers by the services providers.
- The subscriber may choose between a number of services with financial and quality criteria.

All involved parts should bear in mind that once the broadband business model is applied and broadband infrastructures are deployed, quality of service and specific Service Level Agreements (SLA) for the provided services should be ensured. Although today's broadband service suppliers and network providers in Greece are mainly concerned about providing easy internet access and connectivity, in the future, value will certainly weigh on the service level.

It should be noted that the business model described above is proposed only for the Greek case. The adoption of this business model could be useful for countries which present the similar characteristics in broadband penetration as well as similar situation in various broadband penetration determinants (such as cost, broadband regulatory framework, competition in broadband market, private or public incumbent telco etc.) with the Greek case. In countries with different characteristics than Greece (for example higher broadband penetration, various technological solutions available in the market, such as DSL and cable TV), the government policies should support infrastructure competition and not public funding for infrastructure supply. Therefore, these countries would adopt a business model, in which all levels (Level 1 – "Network Passive Equipment", Level 2 – "Network Active Equipment" and Level 3 – "Access, Services, Content" are subject to competition.

Appendix. See Tables 4–9.

Table 4
Sub-cost for network construction.

No	Job description	Unit	Cost per unit
1	*Digging*		
	Trench type X1	m	21,0 €
	Trench type X2	m	22,3 €
	Trench type X3	m	15,0 €
	Out of ground passing	m	21,8 €
2	*Manholes*		
	Manhole type F1 (big)	Item	600,0 €
	Manhole type F1 (small)	Item	423,0 €
	Manhole type F2 (in sidewalk)	Item	293,0 €
3	*Ducts*		
	Duct type F40 mm/32 mm	m	1,3 €
	Duct type F50 mm/44 mm	m	1,4 €
4	*Optical fibre cables*		
	*K*3/2 for micro-duct M2	m	1,0 €
	*K*3/4 for micro-duct M2	m	1,0 €
	*K*3/8 for micro-duct M2	m	1,1 €
	*K*3/12 for micro-duct M2	m	1,2 €
	*K*2/4 for micro-duct M1	m	1,0 €
	*K*2/8 for micro-duct M1	m	1,3 €
	*K*2/12 for micro-duct M1	m	1,3 €
	*K*2/24 for micro-duct M1	m	1,5 €
	*K*2/36 for micro-duct M1	m	1,8 €
	*K*2/48 for micro-duct M1	m	1,8 €
	*K*2/72 for micro-duct M1	m	2,2 €
5	*Micro-ducts*		
	1-Micro-duct 10/8 mm (M1)	m	1,3 €
	4-Micro-duct 10/8 mm (M1)	m	2,5 €
	5-Micro-duct 10/8 mm (M1)	m	2,8 €
	7-Micro-duct 10/8 mm (M1)	m	3,3 €
	24-Micro-duct 5/3,5 mm (M2)	m	3,9 €
	12-Micro-duct 5/3,5 mm (M2)	m	2,3 €
	4-Micro-duct 5/3,5 mm (M2)	m	1,3 €
	Micro-duct branches type 1	Item	20,7 €
	Micro-duct branches type 2	Item	27,8 €
6	*Joint closure*		
	24 Fibre joint closure	Item	417,0 €
	72 Fibre joint closure	Item	939,0 €
7	*Optical fibre terminations*		
	Optical fibre terminations in the nodes	Item	11,0 €
	Optical fibre terminations	Number	11,0 €

Table 5
Sub-cost for network nodes construction.

No	Job description	Unit	Cost per unit
1	*Active equipment*		
	Media convertors	Item	276,79 €
	Users switch	Item	933,45 €
	Access node switch	Item	7.939,40 €
	Core node switch	Item	41.372,21 €
	Wireless point switch	Item	462,75 €
2	*Passive equipment*		
	FOT PatchCords	Item	22,46 €
	PigTails (12×)	Item	85,46 €
	XC PatchCords 5 m.	Item	14,52 €
	User patch panels 12LC-1U	Item	221,70 €
	Distribution node patch panels 48LC-1U	Item	454,00 €
	Access node patch panels 72LC-1U	Item	634,00 €
	Core node patch panels 72 LC - 1U	Item	634,00 €
	Code node active equipment staging	Item	1.540,00 €
	Access node active equipment staging	Item	1.048,00 €
	Nodes passive equipment staging	Item	913,00 €
	User equipment staging	Item	690,00 €
	Optical cable for user in user premises	Item	65,00 €
	User termination box	Item	509,00 €
3	*Housing equipment*		
	Access node housing equipment	Item	5.650,00 €
	Distribution node housing equipment type 1	Item	7.380,00 €
	Distribution node housing equipment type 2	Item	6.560,00 €
	Core node housing equipment	Item	17.250,00 €
	Wireless node housing equipment	Item	5.180,00 €
	A/C	Item	586,50 €
	Core node UPS and generator	Item	11.000,00 €
	Access node UPS	Item	2.000,00 €
	Access control system	Item	644,00 €
	Lockers for nodes	Item	130,0 €
4	*Setup of node*		
	Node up to 10 M2	Item	4.190,00 €
	Node up to 15 M2	Item	5.580,00 €
	Node up to 25 M2	Item	8.370,00 €

Table 6
Sub-cost for passive equipment installation to users premises.

No	Job description	Unit	Cost per unit
1	*Termination box*		
	Termination box for 4 optical fibres	Item	300,0 €
	Termination box for 8 optical fibres	Item	350,0 €
	Splices		2,0 €
2	*Other passive equipment*		
	Optical cable inside user premises	Item	300,0 €
3	*Active equipment*		
	Ethernet switches	Item	1.000,0 €
	Convector from optical to UTP with SFP	Item	300,0 €

Table 7
Sub-cost for wireless equipment.

No	Job description	Unit	Cost per unit
1	*Spar*		
	Spar for wireless base	Item	496,00 €
	Spar for wireless connecting point	Item	1.928,00 €
2	*Active equipment*		
	Wireless base active equipment (WiFi)	Item	2.331,00 €
	Wireless base active equipment (Wimax)	Item	4.232,00 €
	Wireless connecting point active equipment (WiFi)	Item	2.455,00 €
	Wireless connecting point active equipment (Wimax)	Item	1.616,00 €

Table 8
Table for calculation of network expansion form existing users' manhole.

No	Job Description	Quantity	Unit	Cost per unit
1	Reconstruction of closest Joint Closure	1,00	Item	A1
2	Construction of required trench to the user premises (type X3)	X	m	A2
3	Cost of ducts	X	m	A3
4	Cost of manhole in user premises	Z	Item	A4
5	Construction of manhole induction in user premises	1,00	Item	A5
6	Cost of materials and installation inside user premises	Y	m	A6
7	Installation of optical fibre cable into duct	$1{,}05 * (X + D)$	m	A7
8	Installation of optical fibre cable to other infrastructure (except duct)	$1{,}05 * Y$	m	A8
9	Cost of optical fibre cable	$1{,}05 * (X + Y + D)$	m	A9
10	Cost and installation of optical fibre termination box	1,00	Item	A10
11	Termination of optical fibre cable to the termination box	4,00	m	A11
12	Testing and certification of the network	1,00	Item	A12

Table 9
Table for calculation of network expansion form existing distribution manhole.

No	Job description	Quantity	Unit	Cost per unit
1	Reconstruction of closest joint closure	1,00	Item	B1
2	Construction of required trench of type X1	B	m	B2
3	Construction of required trench of type X2	C	m	B3
4	Construction of required trench to the user premises (type X3)	X	m	B4
5	Cost of ducts	$2 * (B + C)$	m	B5
6	Cost of micro – ducts type M1	$3 * (B + C)$	m	B6
7	Cost of micro – ducts type M2	$(B + C + X)$	m	B7
8	Construction of manhole type F1 (if needed)	E	Item	B8
9	Construction of manhole type F2 (if needed)	F	Item	B9
10	Construction of manhole in user premises	Z	Item	B10
11	Construction of manhole induction in user premises	1,00	Item	B11
12	Cost of materials and installation inside user premises	Y	m	B12
13	Cost of optical fibre cable	$1{,}05 * (X + B + C + D + Y)$	m	B13
14	Installation of optical fibre cable into duct	$1{,}05 * (X + B + C + D)$	m	B14
15	Installation of optical fibre cable to other infrastructure (except duct)	$1{,}05 * Y$	m	B15
16	Cost and installation of optical fibre termination box	1,00	Item	B16
17	Termination of optical fibre cable to the termination box	4,00	m	B17
18	Testing and certification of the network	1,00	Item	B18

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